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admission to statehood confirm this truth and illustrate still further the influence of the mining industry. California, the first western State to receive the honor, entered the Union in 1850. Oregon and Nevada, two adjoining States, followed in 1859 and 1864, respectively. Although Utah's population was sufficient before 1870 to admit her with her semi-circle, for other reasons she was detained until 1896. In 1889 and 1890, the second semi-circle, begun abnormally by Colorado in 1876 (already an important mining State), was completed by the admission of Wyoming, Montana, Idaho and Washington. South Dakota was admitted in 1889, also, but not primarily on account of the mining population. Arizona, due in the sixties, and New Mexico due with Idaho and Wyoming, did not gain statehood until a very recent date. Their interests, although mostly mining, were relatively slight; and their populations consisted, beside the miners, mostly of Mexicans and Indians. As the widening waves of discovery spread from California as a center, so the wave of migration set in the same direction; and in the course of thirty years, with constant additions from the East, had beaten back across all the mountains, setting in motion the machinery of development in every State.*

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* Chittenden, H. M. Early Steamboat Navigation on The Missouri River, 1903, Vol. II, pp. 265f.

THE GEOLOGY OF THE LAKE SUPERIOR REGION. A REVIEW*

The Lake Superior Region, noted as a producer both of iron and copper, has been more thoroughly studied than any other area of equal size in the United States. Among those who have worked on some part of the region are a large proportion of the leading geologists of America and also some from Europe.

Since early in the Nineteenth Century, geological surveys, under national, state or private supervision, have usually been in progress. The literature on this region is accordingly so enormous that it is difficult for a student to become familiar with all of it. It is therefore of prime importance to have an analysis of the phenomena and problems of the region as far as it is now understood. This monograph is the first attempt to discuss the region as a whole and, naturally enough, it appears under the auspices of the United States Geological Survey, and has been prepared by the two authors who have been most continuously connected with Lake Superior geological study.

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* The Geology of the Lake Superior Region. By Charles Richard Van Hise and Charles Kenneth Leith. 641 pp., 49 pls., 76 figs. *Monographs* of the U. S. Geol. Surv., Vol. 52, 1911. Washington. 11½ x 9½.

The Lake Superior region, as represented on the accompanying geological map, includes 180,000 square miles. It occupies a part of the southern margin of the great pre-Cambrian shield of northern North America, bordered and overlapped on the south and southwest by later sedimentary rocks. Although the area included in the monograph is so extensive, the portion of most interest is far smaller, for the iron and copper deposits are found only in these pre-Cambrian rocks, and occupy an area of less than 3 per cent of the Lake Superior region. As the authors point out: "The great development of the mineral industry in this region has afforded the geologists unusual opportunity for study... This fortunate combination of a field containing an exceptionally full record of a little-known part of the geologic column with the means of studying it has warranted the study of the pre-Cambrian with a degree of detail that has been practicable in but few other significant pre-Cambrian regions."

A chapter on the history of the region contains an outline of the development of each district, and tables of output. We learn from these that, up to the end of 1909, there had been shipped 449,656,472 gross tons of iron ore, nearly half of which came from the Mesabi range. The third chapter contains a brief history of the geological work and includes a full bibliography.

The authors have been assisted by several associates, particularly Lawrence Martin and W. J. Mead. Professor Martin contributes Chapters 4 and 16 on the Physical Geography and the Pleistocene respectively. The chapter on Physical Geography, illustrated by sketch maps and an excellent relief model, not only summarizes the results previously published, but, in some respects, contributes a new point of view concerning a region of unusual interest. In this chapter the region is divided into three provinces: (1) the Lake Superior Highlands; (2) the semi-circle of lowland plain; (3) the Lake Superior district; and each of these provinces is separately described.

The highlands form a remarkably even peneplain with a general elevation of from 1,000 to 1,700 feet, though with monadnocks which rise to a height of a little over 2,300 feet. This peneplain is described and its erosive features, such as ridges, mesas, monadnocks and valleys, are discussed and interpreted. Perhaps in late Algonkin or early Cambrian time, the peneplain was, in part at least, buried beneath sedimentary deposits and later resurrected. It was, moreover, subjected to warping.

Encircling this highland region on the south, east and west, are horizontal, or nearly horizontal, early Paleozoic strata; and towards the west, Cretaceous strata, the whole forming a belted plain, whose topography is more or less obscured by glacial deposit.

Sunk partly in the lowland belt, but chiefly in the pre-Cambrian highland area, is the basin of Lake Superior, which everywhere, except on the southeast side, is bordered by an escarpment that rises sometimes directly out of the water, sometimes at a distance back from the shore. It rises from 400 to 800 feet above the lake surface, and sinks from 500 to 900 feet below the water.

In considering the origin of this basin, Professor Martin points out that Lake Superior is unlike the other Great Lakes, in that it lies not along the contact between pre-Cambrian and Paleozoic rocks, but in the pre-Cambrian everywhere excepting in the southeast. While admitting the synclinal structure of the Lake Superior basin, he questions the old explanation that the basin is due to this down-folding, for, as he points out, such an old structural basin could neither have remained unfilled for so long a time, nor could it have retained the present abrupt boundaries which bear all the characteristics of topographic youth. He adduces evidence which seems to show that the bounding escarpments are due to faulting, and concludes that the Lake Superior Basin is a *graben,* due either to recent faulting or, more probably, to ancient faults whose escarpments have been buried beneath sedimentary strata and resurrected by later denudation. He holds that glaciation has modified the topographic features only in minor detail.

Chapters 5 to 15 include a painstaking outline of the main features previously worked out in the various ore fields. While these chapters are of much importance they are of particular interest to the local student, the structural and economic geologist, and the miner rather than to the geographer.

Chapter 16, by Professor Martin, discusses the Pleistocene phenomena, describing features of deposit and giving an interpretation of the glacial history. The glacial invasion stripped off the soil in the region north of Lake Superior while south of the lake a heavy mantle of glacial deposit was left. The "influence of glaciation on topography was minor" in importance, but "the effects on soil, drainage, forests, and the subsequent pursuits of man were most profound." The nature of these influences and the various kinds of deposits are discussed and the chapter includes an outline of the history of the expanded marginal lakes associated with the ice recession.

In Chapter 17, which deals with the iron ores, there is a discussion by the authors and W. J. Mead, of the characteristics of the ores and the methods of exploration employed in locating them. These methods include drilling. Not less than 26,500 drill holes have been put down, making a total of 1,363 miles of drilling, at a cost of $21,600,000. Dr. Leith has gained high skill in the study of drill cores, and their interpretation and his remarks upon the significance of drill records are of special importance.

Up to 1910, 335 mines have been worked, and it is estimated that 20.5 per cent. of the known reserves have already been consumed. About 1,905,000,000 tons of ore are estimated to be at present available, 1,600,000,000 tons of it in the

Mesabi range. If this estimate is correct, and if the rate of mining in 1910 should be maintained, the available ores would be exhausted in forty-five years, or in 1956. This estimate is not to be taken too rigidly, for there are variable factors. There is the probability of new ore discoveries, of the use of larger proportions of low grade ores, and of decrease in output, due to a greater use of deposits in other regions. These tendencies toward reduction in rate of exhaustion are opposed to the other tendency toward increase in shipment, through increased industrial demands. No accurate prophecy can be made concerning the future of the Lake Superior iron production. It is to be noted that "prior to 1911 the discoveries have kept well ahead of the shipments"; but it is hardly probable that this will be maintained for very long in the future. In view of the fact that the Lake Superior region produces about 80 per cent. of our iron ore and contains approximately 60 per cent. of the reserves now known to be available, the question of the future of the Lake Superior region is naturally one of the greatest importance." The authors conclude that "while the ores at present available would probably be exhausted within about fifty years if they alone were drawn from, the increasing use of lower-grade ores, already begun, will lengthen this period many times."

In 1907 the average cost of carrying the ore from the upper to the lower lake ports, was 72.16 cents per ton, and the average cost of transportation to the furnaces, $2.14 per ton.

Messrs. Van Hise and Leith hold that the ores are altered parts of chemically deposited sedimentary formations, a few representing originally rich layers that were subjected to only minor secondary change, but most of them underwent extensive secondary concentration, which was, in fact, "the essential means of enriching iron-formation layers to iron ores." The original source of the iron was mainly basic igneous rocks, the iron being removed and later concentrated by meteoric waters, whose activities have been localized by a considerable variety of structural and topographic features, the development of the ore representing a partial metamorphic cycle. The discussion terminates with a genetic classification of the iron ores of the world.

The closing chapters deal respectively with copper in Chapter 18, silver and gold ore in Chapter 19, and general geology in Chapter 20. This monograph will long stand as an adequate discussion of the complex phenomena of a unique region.

RALPH S. TARR.